

- Environment and Territories, 1992
- 8 Edmonds C, Lowry C and Pennefather J. *Diving and Subaquatic Medicine 3rd Ed.* Butterworth and Heinemann, 1992
- 9 Curtis A. Diving incidents: and analysis of the 1995 survey. *Scottish Diver* 1996; 35 (2): 26-28

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PAIN PERCEPTION DURING SCUBA DIVING

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Key Words

Equipment, investigations, pain.

Introduction

It is a common experience during scuba diving that small injuries like scrapes and cuts from sharp stones, shells or wrecks seem to be unnoticed until after the dive. It seems that the threshold for pain is higher during scuba diving than it is when on land. We have no explanation for this phenomenon, and to be absolutely honest, we do not even know if it is true. A study was therefore designed to find out if this experience is real and to explore different explanations for this phenomenon.

It is known that nitrogen is a narcotic gas, and as the content of nitrogen is increased in the tissues during diving, this could offer a possible explanation. Another fact is that nerve conduction from the nociceptors in peripheral tissues is lowered by cooling of the tissues.¹⁻³ Cooling of the skin might thus be an explanation of an increased pain threshold. Another explanation might be that during a dive one is concentrating and ignores pain.

Pain physiology

In 1979, the International Association for the Study of Pain defined pain as *an individual experience of a potential or an actual tissue damage, unpleasant sensory experience, or experienced as such.*

This is a very broad definition. In daily life we often use a very simple classification such as acute or chronic pain. This does not work very well in the orthopaedic clinic, so in our clinic and in research, we use another classification.

Nociceptive pain is an acute pain which is caused by damage to tissues, either actual or potential damage. This is a type of pain one experiences when one cuts or bruises oneself and when one breaks a leg.

Neurogenic pain is caused by a prior damage to one's neural tissues and gives rise to phantom limb pain, trigeminal neuralgias, reflex sympathetic dystrophies and so on.

Another group is the chronic pains. Chronic pain syndromes, such as chronic low back pain etc., are a very difficult group to treat.

Finally there is psychogenic pain, a group of pain syndromes associated with psychic disturbances.

When a painful stimulus is applied to peripheral tissues a number of nociceptors are engaged (mechanoreceptors, thermo-receptors or chemo-receptors) and impulses are conducted along two types of nerves to the posterior horns of the medulla. First through thick myelinated fibres which give a very sharp and distinct pain and later by thin nerve fibres, without myelin, which give a duller and more lasting pain. This conduction can be modulated by other non-painful sensory input, the so-called gate control.

When one damages the nociceptors in the periphery there is also an inflammatory reaction with an outflow of vasoactive agents, such as histamine, prostaglandins etc.

The pain impulses are conducted through the posterior columns of the medulla to the brain where they enter different pain centres. Most importantly, one in the cortex which is responsible for the localisation of pain. But also in the cortex there is a descending pain inhibition centre from which signals are sent down to the spinal cord to further filter pain signals. Other centres are in the limbic system, responsible for the emotional reaction to pain, the basal ganglia which are responsible for the tremor or dizziness which are seen in pain and the hypothalamus, responsible for the discomfort and nausea which often occurs with pain.

Methods

In order to measure pain levels and thresholds we, at the Danish Pain Research Centre, normally use an electronic pressure algometer. This electronic device measures pain

by sustaining a known pressure, which can be changed if desired, to an extremity. Knowing how much pressure is being applied we can define how much pain the patient has. By increasing the pressure we can find the pain threshold which is defined as the point where the patient decides that the pain is intolerable and wishes to be released. We can refine this by using the patient's reaction. This is done by using a visual analogue scale on which the patient can mark his or her pain perception.

In order to make our measurements under water, we had to develop apparatus to test pain by putting a known pressure on a finger and skin temperature. For that pressure the test person can, using a visual analogue scale, tell the investigator how much pain he feels. The pressure can be increased until the pain is so high as to be intolerable, what we call the "pain threshold". The next step was to compare this very simple and cheap apparatus with the laboratory equipment. We did that in 14 volunteers and Table 1 shows a very good correlation between the two machines, although the units of measurement are different on the two machines.

After an initial pilot study we made some small changes and did a pool test in 14 volunteers using our home made pressure algometer (Fig 1). We also measured the skin temperature at the tip of the finger in these patients to find out whether the temperature was altering nerve conduction.

Results

Figure 2 shows the results in our 14 volunteers. There are significantly higher pain thresholds during diving. The 14 volunteers were measured just before they went into the

TABLE I
PAIN PERCEPTION LABORATORY TESTS

Units	Diving algometer		"Sometric" electronic Pain unbearable (kPa)
	Pain detected (Newtons)	Pain unbearable (Newtons)	
1st test	25.2	40.5	308.3
2nd test	25.2	40.9	288.9
3rd test	23.7	40.6	291.1



Figure 1. Diver underwater with right index finger in the "home made" algometer.

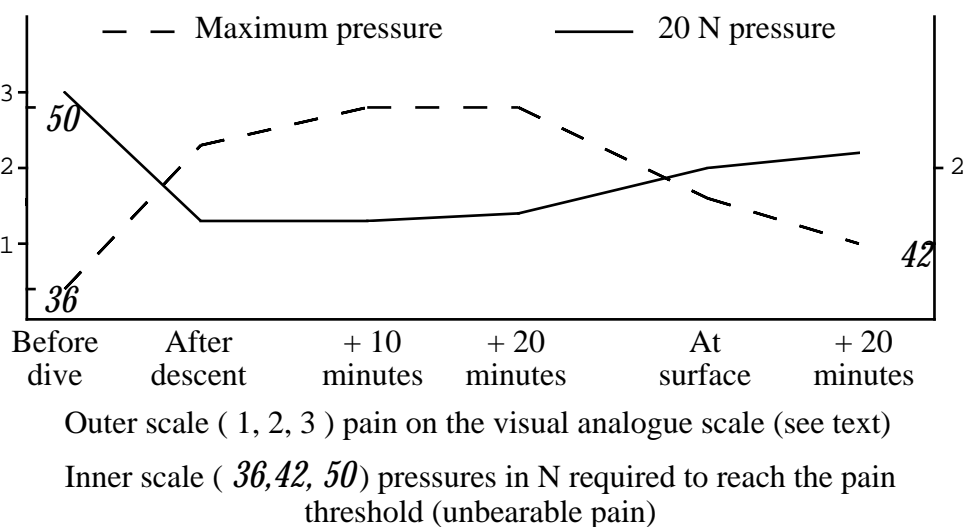


Figure 2. Showing rise in pain threshold and decrease in pain perception in 14 divers while underwater.

pool. They went to 4 m and immediately after the descent we did another test. The test was repeated after 10 minutes, after further 10 minutes, after they had reached the surface and then 20 minutes later. The pain threshold is higher during the dive and comes back to almost normal after a while on land. When we pressed with 20 Newtons less pain was felt and underwater the pain scores were significantly reduced.

Further studies are necessary in order to find an explanation for this phenomenon. We are planning to go on with this study at different depths and different temperatures. Also, a test in a pressure chamber has been planned.

Audience participation

Unknown speaker

Why call unbearable pain the “pain threshold”? Surely a pain threshold is when pain is first felt.

Karsten Kroener

Perhaps we should have called it the “pain tolerance limit” but we chose “pain threshold”.

Terry Brown, Alabama

There was a single case study in Undersea and Hyperbaric Medicine about the use of hyperbaric oxygen (HBO) in reflex sympathetic dystrophy, which is a tremendously difficult disorder to treat. I also know of a

person with a chronic low back pain who was treated with HBO for decompression illness and his back pain got better. I wonder if you could comment about the use of HBO just for pain.

Karsten Kroener

These syndromes are very difficult to treat. These patients have tried practically every type of treatment. I would welcome the opportunity to try HBO, especially for the reflex sympathetic dystrophies, a very difficult group to treat. But I have no experience myself.

References

- 1 Kochs E. Electrophysiological monitoring and mild hypothermia. *J Neurosurg Anesthesiol* 1995; 7 (3): 222-228
- 2 Kennett RP and Gilliat RW. Nerve conduction studies in experimental non-freezing cold injury: II. *Muscle-Nerve* 1991; 14 (10): 960-967
- 3 Koczocik-Przedpelska J and Gorski S. Double pattern of relationship between skin temperature, thermoregulation and sensory nerve conduction. *Electromyogr Clin Neurophysiol* 1990; 30 (7): 435-442

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